# Effects of Different LED Light Intensities on the Physiological and Biochemical Characteristics of Camellia oleifera Seedlings: Postprint

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## Abstract

To provide beneficial reference and scientific basis for Camellia oleifera seedling cultivation, this study employed two-year-old 'Changlin 4' Camellia oleifera cutting seedlings as experimental material to measure and analyze the soluble substance content, endogenous hormone levels, and antioxidant enzyme activities under different light intensity treatments of LED red-blue 1:9 composite light, thereby exploring the differences and variation patterns of physiological and biochemical characteristics of Camellia oleifera seedlings under various LED light intensity treatments. The results demonstrated that: under the 100 mol · m-2 · s-1 treatment, seedlings exhibited the highest ZR content and POD activity, along with the lowest MDA content, but showed the lowest soluble sugar, IAA, and GA contents; under the 150 mol · m-2 · s-1 treatment, seedlings displayed the highest ABA content, while having the lowest soluble protein content and SOD activity; under the 200 mol · m-2 · s-1 treatment, seedlings possessed the highest SOD activity, but the lowest POD activity, and the highest MDA content; under the 250 mol · m-2 · s-1 treatment, seedlings achieved the highest soluble protein, soluble sugar, free amino acid, IAA, and GA contents, as well as CAT activity; under the 300 mol · m-2 · s-1 treatment, seedlings had the lowest free amino acid, ABA, ZR contents, and CAT activity. Compared with other treatments, the 250 mol · m-2 · s-1 treatment was more favorable for enhancing various physiological and biochemical indicators of 'Changlin 4' Camellia oleifera seedlings, representing a relatively ideal light intensity for Camellia oleifera seedling cultivation.

## Full Text

# Effects of Different LED Light Intensities on the Physiological and Biochemical Characteristics of Oil-Tea Camellia Seedlings

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### Abstract

This study investigated the effects of different light intensities from LED red-blue composite light (1:9 ratio) on soluble substance content, endogenous hormone levels, and antioxidant enzyme activity in oil-tea camellia seedlings, using two-year-old cutting seedlings of *Camellia oleifera* 'Changlin-4' as experimental materials. The results demonstrated significant variations in physiological and biochemical characteristics across different light intensity treatments. At 100 mol · m$^{2}$ · s$^{1}$, seedlings exhibited the highest zeatin riboside (ZR) content and peroxidase (POD) activity, along with the lowest malondialdehyde (MDA) content, but showed the lowest levels of soluble sugar, indole-3-acetic acid (IAA), and gibberellin (GA). The 150 mol · m$^{2}$ · s$^{1}$ treatment produced the highest abscisic acid (ABA) content and the lowest soluble protein content and superoxide dismutase (SOD) activity. At 200 mol · m$^{2}$ · s$^{1}$, seedlings displayed peak SOD activity but minimal POD activity and maximal MDA content. The 250 mol · m$^{2}$ · s$^{1}$ treatment yielded the highest values for soluble protein, soluble sugar, free amino acid content, IAA, GA, and catalase (CAT) activity. The 300 mol · m$^{2}$ · s$^{1}$ treatment resulted in the lowest levels of free amino acids, ABA, ZR, and CAT activity. Compared with other treatments, the 250 mol · m$^{2}$ · s$^{1}$ LED red-blue composite light (1:9 ratio) was most beneficial for enhancing the physiological and biochemical indicators of 'Changlin-4' oil-tea camellia seedlings, representing an optimal light intensity for seedling cultivation.

**Keywords:** Nonwood forest science; seedling cultivation; soluble substances; endogenous hormones; antioxidant enzymes

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## Introduction

Light intensity is a critical environmental factor in plant growth and development, profoundly influencing photosynthetic characteristics, physiological metabolism, and quality formation. Plants achieve optimal growth only under suitable light conditions. Insufficient light intensity leads to etiolation, enlarged and thinner leaves, while excessive intensity causes wilting and produces smaller, thicker leaves. Both conditions induce photoinhibition, though plants have evolved protective mechanisms such as reactive oxygen species (ROS) scavenging systems that can eliminate ROS within certain limits, thereby reducing cellular damage.

Oil-tea camellia (*Camellia oleifera* Abel.) is a crucial woody oil species in southern China and ranks among the world' s four major woody oil crops. Widely distributed across southern China, its primary product—tea oil—is rich in unsaturated fatty acids and vitamin E, earning it the reputation of "oriental olive oil." With increasing national emphasis on the oil-tea camellia industry through supportive policies and subsidies, cultivation areas have expanded dramatically, creating a growing demand for improved seedlings that currently outpaces supply. To identify methods for enhancing seedling propagation efficiency, our research team previously investigated the effects of LED light quality on oil-tea camellia seedling growth and identified the optimal light quality ratio for 'Changlin-4' seedlings. Building upon this foundation, the present study examined how different LED light intensities affect soluble substance content, endogenous hormone levels, and antioxidant enzyme activity in 'Changlin-4' cuttings under red-blue composite light (1:9 ratio), aiming to provide scientific guidance for light intensity selection in oil-tea camellia seedling production.

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## Materials and Methods

### 1.1 Experimental Materials and Design

The experiment was conducted from April to June 2017 at the Research Institute of Subtropical Forestry, Chinese Academy of Forestry. Two-year-old 'Changlin-4' oil-tea camellia cuttings of uniform growth (approximately 13.9 cm in height and 2.57 mm in basal diameter) were selected from the Jiangshan Forestry Seed and Seedling Breeding Center in Zhejiang Province. Seedlings were individually transplanted into plastic pots (14 cm diameter × 11 cm height) filled with imported German K-brand peat moss substrate. Each treatment comprised 36 seedlings with three replications. Baseline measurements of seedling height and basal diameter were recorded. Light treatments commenced on April 4.

LED light strips were purchased from Shenzhen Libo Lighting Co., Ltd., with specifications as follows: red LED peak wavelength 661 nm, half-width 19.7 nm, color purity 0.993; blue LED peak wavelength 454 nm, half-width 20.1 nm, color purity 0.982. Using red-blue composite light at a 1:9 ratio, five light intensity treatments were established: L1 (100 mol · m $^{2}$ · s $^{1}$), L2 (150 mol · m $^{2}$ · s $^{1}$), L3 (200 mol · m $^{2}$ · s $^{1}$), L4 (250 mol · m $^{2}$ · s $^{1}$), and L5 (300 mol · m $^{2}$ · s $^{1}$). The cultivation system consisted of steel frames covered with black shading cloth, with adjustable light sources positioned above the plants. All treatments received a 12-hour photoperiod (06:30–18:30), and room temperature was maintained at 25 ± 1°C. Physiological indices were measured on day 60 (June 3).

### 1.2 Index Determination

For each treatment, 12 seedlings were randomly selected (four per replication). The second to third leaves from the shoot apex were collected, cleaned, and finely shredded. A 0.1 g sample was weighed using a 0.1 mg precision balance, placed in a 2 mL cryogenic centrifuge tube, snap-frozen in liquid nitrogen, and stored at -80°C until analysis.

Soluble protein content, free amino acid content, soluble sugar content, MDA content, and activities of SOD, POD, and CAT were determined using assay kits from Keming Biotechnology Co., Ltd. (Suzhou, China). The specific kits included: Coomassie brilliant blue protein assay (KMSP-2-W), amino acid assay (AA-2-W), plant soluble sugar assay (KT-2-Y), MDA assay (MDA-2-Y), SOD assay (SOD-2-Y), POD assay (POD-2-Y), and CAT assay (CAT-2-Y). Procedures and calculations followed manufacturer protocols.

Endogenous hormone contents (IAA, GA, ABA, and ZR) were determined by ELISA and analyzed by China Agricultural University.

### 1.3 Data Processing

Each treatment and replication was randomly sampled three times. Data were analyzed using Excel 2007 and SPSS 11.5 software. One-way ANOVA and Duncan' s multiple range test were used for significance testing.

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## Results

### 2.1 Effects of Different LED Light Intensities on Soluble Substance Content in Oil-Tea Camellia Leaves

Soluble protein content in leaves exhibited a decreasing-increasing-decreasing trend with increasing light intensity. The L4 treatment (250 mol · m $^{2}$ · s $^{1}$) produced the maximum soluble protein content of 5.058 mg · g $^{1}$, significantly higher than L2 and L5 treatments. The L2 treatment showed the minimum value, though not significantly different from L1, L3, and L5 treatments .

Soluble sugar content showed no significant differences among treatments, with the highest value observed in L4 and the lowest in L1 .

Free amino acid content generally increased then decreased with rising light intensity. The L5 treatment yielded the lowest content at 12.131 mg · g $^{1}$, significantly lower than other treatments. The L4 treatment produced the highest value, 1.35 times that of L5, while L1 through L4 treatments showed no significant differences among themselves .

MDA content displayed an initial increase followed by a decrease with increasing light intensity. The L1 treatment resulted in the lowest MDA content at 25.518 nmol·g 1, significantly lower than other treatments. The L3 treatment produced the highest value, followed by L2, then L4 and L5 .

### 2.2 Effects of Different LED Light Intensities on Endogenous Hormone Levels

IAA and GA contents generally increased then decreased with rising light intensity. The L4 treatment produced the highest IAA and GA contents at 56.637 and 7.967 ng·g 1, respectively, significantly higher than other treatments. L5 and L3 treatments ranked next, significantly higher than L1 and L2. The L1 treatment showed the lowest values at 41.475 and 5.454 ng·g 1, not significantly different from L2 .

ABA content also increased then decreased with rising light intensity. The L2 treatment yielded the highest ABA content at 77.789 ng·g 1, followed by L1, both significantly higher than other treatments. L3 and L4 treatments were next, significantly higher than L5 .

ZR content gradually decreased with increasing light intensity. The L1 treatment produced the highest ZR content at 8.006 ng·g 1, significantly higher than L5. No significant differences were observed among L2, L3, and L4 treatments .

### 2.3 Effects of Different LED Light Intensities on Antioxidant Enzyme Activity

Antioxidant enzyme activities generally showed a decreasing-increasing-decreasing trend with rising light intensity .

SOD activity peaked in the L3 treatment at 470.202 U·g 1, followed by L1 and L4 treatments, all significantly higher than L2 and L5. The L2 treatment showed the lowest activity, not significantly different from L5.

POD activity showed no significant differences among treatments, with the highest value in L1 and the lowest in L3.

CAT activity reached its maximum in the L4 treatment at 425.192 U·g 1, significantly higher than other treatments and 1.75 times that of L5. The L5 treatment produced the lowest value, not significantly different from L1, L2, and L3.

## Discussion

### Effects on Soluble Protein and Soluble Sugar Content

Soluble protein is an important physiological and biochemical indicator closely related to plant stress resistance. This study found that soluble protein content in 'Changlin-4'oil-tea camellia leaves initially increased then decreased with light intensity from 100 to 300 mol · m $^{2}$ · s $^{1}$, reaching maximum at 250 mol · m $^{2}$ · s $^{1}$. This indicates that appropriate light intensity within a certain range can promote soluble protein accumulation, consistent with findings in *Hemerocallis* spp. and *Lagenaria siceraria*.

Soluble sugars are vital organic components that play important roles in plant growth and development. This study revealed that soluble sugar content in 'Changlin-4' leaves also increased then decreased with rising light intensity, peaking at 250 mol · m $^{2}$ · s $^{1}$. This suggests that moderate light intensity enhancement can improve soluble sugar content, corroborating results from studies on *Lagenaria siceraria*, *Dendrobium nobile*, *Spathiphyllum kochii*, and *Lactuca sativa*.

### Effects on Antioxidant Enzyme Activity and MDA Content

SOD, POD, and CAT are crucial antioxidant enzymes that continuously scavenge ROS generated during metabolism and stress, preventing membrane lipid peroxidation and associated damage to plant development. However, antioxidant enzymes cannot eliminate all ROS, and accumulated ROS gradually increase membrane lipid peroxidation. MDA content serves as a key indicator of membrane lipid peroxidation severity. This study found that at 100 mol · m $^{2}$ · s $^{1}$, 'Changlin-4' seedlings showed high SOD, POD, and CAT activities with minimal MDA content, indicating effective ROS scavenging and low membrane damage. At 150 mol · m $^{2}$ · s $^{1}$, low antioxidant enzyme activities and high MDA content suggested inadequate ROS removal and severe membrane peroxidation. As light intensity further increased, antioxidant enzyme activities rose then fell while MDA content gradually decreased, indicating that higher light intensities established a dynamic equilibrium between ROS production and elimination, stabilizing membrane structure and function.

### Effects on Endogenous Hormone Content

IAA and GA contents in 'Changlin-4' leaves increased then decreased with rising light intensity, peaking at 250 mol · m $^{2}$ · s $^{1}$ and reaching minimum at 100 mol · m $^{2}$ · s $^{1}$. Conversely, ABA content gradually decreased with increasing light intensity, showing higher values at 100 and 150 mol · m $^{2}$ · s $^{1}$ and the lowest at 300 mol · m $^{2}$ · s $^{1}$. Since IAA and GA promote growth while ABA is associated with senescence, the 250 mol · m $^{2}$ · s $^{1}$ treatment likely promotes seedling growth, whereas 100 and 150 mol · m $^{2}$ · s $^{1}$ treatments are less favorable. These findings align with research on *Phalaenopsis*.

Compared with other treatments, the LED red-blue composite light (1:9 ratio) at 250 mol·m ²·s ¹ produced 'Changlin-4' seedlings with maximal soluble protein, soluble sugar, free amino acid, IAA, and GA contents, along with highest CAT activity and relatively high SOD and POD activities, while maintaining low ABA and MDA levels. This demonstrates that 250 mol·m ²·s ¹ LED red-blue composite light can enhance physiological function, promote accumulation of growth-promoting hormones, and improve stress resistance in oil-tea camellia seedlings, representing an appropriate light condition for seedling cultivation.

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*Note: Figure translations are in progress. See original paper for figures.*